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DRAWING WITHOUT EYESIGHT. EVIDENCE FROM CONGENITALLY BLIND LEARNERS

The paper investigates the formal characteristics of drawings made by congenitally blind children and teenagers as well as the possibility and level of accuracy in the recognition of these drawings by sighted individuals. The study involved children and students aged seven to fifteen years. The formal features predominant in the drawings analyzed were typical for the failed realism stage. As an additional goal of the study, we investigated the usefulness of the transfograph as an educational resource supporting the introduction of tactile graphics to congenitally blind persons. Drawings made by blind subjects before and after training with a transfograph revealed a similar level of difficulty with their identification. However, following a prompt about the subject of each drawing, those made after the training were described by judges as more easily identifiable. In addition, the drawings made after training showed fewer features of failed realism.

Keywords: congenitally blind persons; development of drawing skills; imagery; tactile graphics; transfograph.

THEORETICAL INTRODUCTION

The aim of the study was to analyze the drawing skills of blind learners and to test the usefulness of the transfograph as a typhlopedagogical aid supporting their drawing development.

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Understanding raised-line drawings

Understanding raised-line drawings involves the ability to interpret a drawing explored by touch. In the case of representational drawings, understanding means the identification of the objects depicted. The ability to recognize the objects drawn is of great importance in the education of blind people. Unfortunately, the process of recognizing what has been depicted is not so fast as in the case of exploring drawings by means of the sense of sight and requires more effort, partly due to the need for the imagery processes to be engaged.

The significance of drawing in the education of blind students. The use of tactile graphics can support development as well as help individuals deprived of visual experience acquire knowledge about the world (see Szubielska & Niestorowicz, 2013). The inability to understand various kinds of visual representations hinders and sometimes even prevents effective knowledge acquisition (e.g., in areas such as geography or biology) as well as the acquisition and refinement of concepts. Many objects (e.g., stars, exotic animals, microorganisms) are impossible to get acquainted with via sensory modalities other than vision; it is also very difficult to communicate information concerning some features of those objects verbally. What is an excellent source of information for a blind person in such situations is tactile drawings, which virtually any parent or teacher can make on their own. Unfortunately, in many countries teaching tactile graphics is an underestimated area in the education of people with visual dysfunction. For example, as recently as the 1990s, in Italy, children could be found who had had no experience with tactile illustrations and had never tried to make a drawing on their own (D'Angiulli & Maggi, 2003). A survey conducted in Poland showed that about 35 percent of blind respondents had never encountered tactile graphics, and nearly half of the sample reported that they could not use drawings (Czerwińska, 2008). At present, more and more initiatives are undertaken whose aim is to facilitate access to educational drawing materials for the blind (Claudet, 2009), but much remains to be done in this area.

Why does the use of raised-line drawings present a problem to blind people? The difficulties blind people encounter in interpreting and producing representational drawings largely stem from the use of conventions reflecting the principles of visual perception – the principles that govern seeing directly translate into drawing conventions (Zeki, 1999). Among other elements, the typical way of depicting objects or scenes from a particular point of view involves reflecting angular size in drawings, where the distance of the object from the observer is taken into account, or the use of interposition, also referred to as occlusion, which consists in nontransparent objects in the line of vision obscuring one another (see Francuz, 2013; Janowski, 2007; Młodkowski, 1998). These techniques may be regarded as monocular indicators of depth. Sighted people automatically use them to discern the third dimension in flat images.

Every object in a drawing can be represented geometrically (as a projection) or in perspective. An object represented as a projection has its real shape, with proportions unchanged; however, this manner of representation gives no idea of the entirety of a given spatial form. Perspective drawing represents three-dimensional objects using optical foreshortening, which changes the proportions of these objects and results in their seeming shapes being depicted (Roliński, 1962). Linear perspective makes it possible to present three-dimensional objects on a surface in such a way that the observer has a sense of depth (Gill, 1997).

Blind people may have difficulties with understanding both projections and perspective drawings. Difficulties in understanding geometrical drawing may stem from the fact that, when touching an object, blind people explore it from many sides at the same time (cf. Heller, 2006). Understanding perspective drawing can present even greater difficulties to blind people – this task requires considerable preparation under the guidance of a specialist in typhlopedagogy, which still does not guarantee success in the form of correct interpretation (Chojecka, Magner, Szwedowska, & Więckowska, 2008). These difficulties may stem from the fact that the blind may perceive the size of the object they touch as constant, focusing on linear rather than angular size (cf. Arditi, Holtzman, & Kosslyn, 1988; Szubielska & Marek, 2015). They may also draw erroneous conclusions concerning objects obscuring one another – that is, interposition (cf. Farrenkopf & Davidson, 1992). As a result, a schematic drawing of a table in the form of a simple projection is interpreted by many blind children as simply representing three lines (Marek, 1997), and the way blind learners typically draw a table is by representing it as a roughly square-shaped top with four rectangular legs stretching outwards from its corners (see Kennedy, 1993; Piskorska, Krzeszowski, & Marek, 2008).

The role of imagery in the interpretation of tactile representational drawings. Understanding a representational drawing requires being aware of the analogy between the two-dimensional representation of the world, not typical for blind people, and the three-dimensional object. In order to discover this analogy, it is necessary to engage imagery processes. This is confirmed by practitioners working with blind students (e.g., Więckowska, 2009). What is more, correlations between imagery abilities and the ability to recognize drawings were found in studies conducted among blind adults (Dulin & Hatwell, 2006) and secondary-school children (Szubielska & Marek, 2012).

An additional difficulty in the process of imagining what a drawing "viewed" by touch represents is the fact that such a drawing is explored relatively slowly (compared to visual perception, which gives a sense of immediate perception of the object). As a result, it is necessary to store information about the previously touched fragments of the picture in the working memory while simultaneously perceiving other fragments, mentally putting the explored picture together into a whole and giving an interpretation to this whole. It turns out that this can be as difficult for sighted individuals with their eyes closed as it is for congenitally blind people (Pathak & Pring, 1989).

Transfograph. A tool that is enormously helpful in explaining the concept of orthogonal projection to a blind person is a device called transfograph (Marek, 1997; see Piskorska el al., 2008). It consists of models of various pieces of furniture and a wooden box with replaceable slide-in lids with apertures in them that match the contours of particular furniture pieces in shape. When the model of a furniture piece has been slipped through the aperture in the wooden lid, the elements that are inside the box disappear and the only thing remaining above the lid is the side edge, identical in shape with the orthogonal projection of a given model.

Numerous case studies show that this tool helps individuals deprived of visual experience to understand the concept of representational drawing and that training with a transfograph is an encouragement to make one's own attempts at producing raised-line illustrations (Marek & Szubielska, 2011). It has also been found that congenitally blind students (those examined were aged 6-15 years) who have undergone training with the transfograph reach ceiling effects in the task of identifying objects represented in raised-line drawings (Marek & Szubielska, 2013). Moreover, analyzing case studies, Szuman (1967) found that learning the contour of an object (by outlining it) helps blind learners more accurately reproduce the shape of the objects drawn.

Drawing development in blind people

On the one hand, in the case of blind people drawing on one's own seems to be an even more difficult task than interpreting tactile graphics (Heller, Calcaterra, Tyler, & Burson, 1996). On the other hand, in favorable circumstances blind people do engage in drawing activity. What is more, all evidence suggests that their drawing development proceeds in stages, just like that of sighted people.

Drawing development in blind vs. sighted people. In blind people, drawing development proceeds in a similar way as in sighted individuals. Kennedy (1993) observed that in both populations the desire to represent is earlier than the ability to capture the likeness of the object depicted. Just like in the sighted, the development of drawing skills in the blind may occur spontaneously, as a result of making successive attempts to draw (D'Angiulli & Maggi, 2003). Moreover, case studies (D'Angiulli & Maggi, 2003; Kennedy, 1993) and experimental studies (Millar, 1975) demonstrate that blind people go through almost the same stages in this development as sighted people do. The difference is that the blind achieve those stages with a certain delay compared to the sighted, and the stage of visual realism, in which perspective drawings are made, is almost unattainable for them (Heller, Kennedy, & Joyner, 1995; Shiu & I, 2010). However, there are cases of highly gifted blind individuals who use linear perspective in their drawings (see e.g., Kennedy & Juricevic, 2003, 2006).

Stages of drawing development. The beginning of drawing development in sighted people is connected with the pleasure the child experiences when observing the effects of his or her activity – the mark left by a colored pencil on a sheet of paper. Luquet (2001/1927) calls this developmental period the scribbling stage and believes that the drawings made in this period do not intentionally represent anything. First attempts at representation may reflect the child's perception of reality, not necessarily based on visual perception; for instance, sensations received by touching an object may be as important as seeing that object (Piaget, 1972). According to Luquet (2001/1927), with age, drawing is more and more strongly and intentionally linked with capturing the likeness of the item being drawn. This author refers to further stages of drawing development as accidental, failed, intellectual, and visual realism. Accidental realism is associated with producing so-called representational scribbles. However, the author of the drawing specifies what is represented in it when a certain pattern has already been scribbled on paper (after meaning has been attributed to it, the pattern may still be subject to slight modifications). In the preschool age, in sighted children, there is a development of symbolic representation of reality in the form of a drawing (Kielar-Turska, 2000). Failed realism is attained by sighted children starting from about the age of 3; in this stage, the child intends to represent a specific thing in a drawing but is still unable to capture its likeness in the image produced. Towards the end of the preschool period and at the beginning of the school period, the drawing development of sighted children is in the stage of intellectual realism. A child in this stage concentrates on what he or she knows about the object drawn, not on what it looks like; for example, a figure portrayed in profile has two eyes. Finally, drawings made in the stage of visual realism contain only that which the observer is able to see from a particular point of view. Importantly, this does not mean that the author of the drawing has fully developed skills connected with applying the principles of perspective – this depends on individual talents and their practice under an art teacher's guidance (Jolley, 2010).

Each stage of development, regardless of the subject matter of the pictures produced, is characterized by the occurrence of certain formal elements in drawings (see Lowenfeld & Brittain, 1977; Luquet, 2001/1927). In the failed realism stage, children typically omit many components of the objects they draw and create an image using simple geometrical shapes. The elements drawn are placed next to one another, without perspective being applied and without the spatial relations between objects being indicated. In the phase of intellectual realism, the child begins to notice the relations between the objects in his or her surroundings. He or she often arranges them all on the base line (e.g., on the floor), making a so-called line-based drawing. In this stage, the drawing may also have the form of a plan. Although the objects drawn are rather schematic in shape, they have quite many details. They are usually represented using orthogonal projection. Moreover, a phenomenon called transparency occurs in these drawings – objects do not obscure one another: they are superimposed on one another. The following are also characteristic for this stage of drawing development: so-called X-ray drawings – multiple points of view represented simultaneously in one picture (e.g., a child draws a house as seen from outside, and at the same time depicts what is taking place inside it); drawings resembling comic strips – they are sequences of images, arranged one after another; folding-out drawings – the space resembles an unfolded model, with some objects placed upside down. In the stage of visual realism, first attempts at perspective representation are made – in the form of linear perspective. Pictures are drawn from one point of view only. An indicator of depth appears – namely, interposition. Aerial perspective and chiaroscuro are also applied. There are still many details in the drawings, characteristically represented with exaggerated precision (e.g., patterns on clothes).

Drawing as a message. A drawing performs both esthetic and informational functions (Hohensee-Ciszewska, 1976). The informational function is met when a representational drawing is identifiable to the recipient. It is very difficult to guess what is represented in drawings produced in the stages of scribbling, accidental realism, or even at the beginning of the failed realism phase. By contrast, content identification is highly probable in the case of drawings made during the stage of intellectual realism and should not present any problems either in the case of sketches drawn in the visual realism stage. The recognizability of drawings – that is, the identification of the depicted objects or scenes by the recipient (cf. D'Angiulli & Maggi, 2003) – can therefore be treated as an indicator of drawing development level.

RESEARCH PROBLEMS AND HYPOTHESES

Analysis of the literature reveals that the drawing development of blind children and adolescents is significantly delayed compared to the development of their sighted peers. It is often difficult to identify what their pictures represent. Only in exceptional situations do blind people attain the stage of visual realism in their drawing development. A question therefore arises: What formal elements dominate in drawings made by blind students? We put forward hypothesis H1: In drawings made by blind learners there are more formal elements characteristic for the stages of failed and intellectual realism than ones typical for the stage of visual realism. The next research question concerned the effectiveness of the transfograph: Does training with this tool support drawing development in blind people? We put forward hypothesis H2: Drawings made by blind learners after training with a transfograph are more recognizable than those made before the training. This tool explains the concept of simple projection and makes it possible to understand graphic conventions, which should contribute to a more accurate depiction of the shape of the object drawn and, consequently, to the object's likeness being captured more accurately in a blind person's drawing. We therefore put forward hypothesis H3: Drawings made after training with a transfograph exhibit a higher level of drawing development (which may manifest itself in a decrease in the number of features associated with earlier stages of drawing development or an increase in the number of features characteristic for later stages) than drawings made before training.

METHOD

Participants

The participants were 11 congenitally blind learners (7 girls and 4 boys; 6 completely blind and 5 with light perception) aged 7.0 to 15.6 years (M = 12.9, SD = 3.0). All of them attended schools for blind and low-vision students. They had some experience in using tactile graphics, acquired during classes, but this experience mainly came down to perceiving tactile drawings rather than creating them on their own.

Materials

The research material was special plastic sheets for making raised-line graphics, used with a rubber pad and a stylus. We also used a transfograph in the study – several models of furniture, a few slide-in lids with apertures of various shapes, and a tactile book with drawings representing projections of the furniture models.

Procedure

The study was carried out in a design with repeated measurement. Both in the pretest and in the posttest, the learners' task was to make three raised-line drawings concerning selected subjects. The subjects were grouped into three categories: (1) objects whose shape can be explored entirely by touch; (2) objects whose shape cannot be explored entirely by touch; (3) scenes. In order not to impose any particular subject on the participants, we suggested selecting one of the objects to draw in the case of each thematic category in the pretest. The categories comprised, respectively: (1) an apple, a pear (two learners said they were able to draw neither an apple nor a pear, but they could draw a table instead as an example of an object that it is possible to get acquainted with entirely by touch, which they were allowed to do); (2) a house, a tree; (3) a room, a kitchen. In the posttest, the learners were asked to draw pictures again on a subject of their choice. The drawing time was unlimited. Between the pretest and the posttest, training with a transfograph took place. Its time and intensity were adjusted to the students' individual needs.

Each drawing was examined by two teams of two judges. The drawings were viewed and rated individually, in a random order, being displayed as scanned images on a computer screen. The first team (a woman aged 37 and a man aged 38, with higher education) rated the recognizability of pictorial representations according to the procedure proposed by D'Angiulli and Maggi (2003). The rating began with answering the question of whether the judge recognized (without any clue being provided) what the drawing represented, and if so – he or she was asked to write down what the drawing represented in their opinion. Next, the title of the drawing was given, and the judge assessed on a 7-point scale how well the author of the drawing managed to represent the object (the extremes of the scale were labeled as follows: 1 – *not at all*; 7 – *perfectly*).

The other team of judges (women with higher education, aged 35 and 39), knowing the title of the picture and the participant's comments about the objects depicted (if the participant made any such comments spontaneously while drawing), rated the formal features of the drawing. Before the rating, it was explained to the judges what each of the formal features was characterized by (verbal explanations were provided and example drawings were shown – different than those rated later, with the formal features present in them). In the case of two categories of drawings – objects whose shape can be learned entirely by touch and objects which it is impossible to explore in their entirety by touch – the judges rated the presence of 12 formal features, plus additional six features in the case of scenes. A description of the analyzed features, including the developmental stage they are related to and the categories of drawings that were subject to assessment in terms of a given feature, is presented in Table 1.

Table 1
Analyzed Formal Features of Drawings

Feature evaluated	For which stage of drawing development is it a characteristic feature?	Which drawings were rated?
Simple geometric shapes	failed realism	all categories
Omitting many elements	failed realism	all categories
Elements placed next to one another	failed realism	scenes only
The use of orthogonal projection	intellectual realism	all categories
X-ray drawings	intellectual realism	all categories
Drawings resembling comic strips	intellectual realism	all categories
Folding-out drawing	intellectual realism	all categories
Schematic shape	intellectual realism	all categories
A large number of details	intellectual realism	all categories
Transparency	intellectual realism	all categories
Line-based drawing	intellectual realism	scenes only
Drawing in the form of a plan	intellectual realism	scenes only
Attempts at linear perspective	visual realism	all categories
Excessive detail	visual realism	all categories
Interposition	visual realism	scenes only
Planes in the picture	visual realism	scenes only
Aerial perspective	visual realism	scenes only
Chiaroscuro	visual realism	scenes only

RESULTS

Four participants reported unwillingness to make drawings. A female student aged 14.5 years categorically refused to draw anything. Three other participants refused to do parts of the work: a male student aged 7.1 years drew only an apple and a tree in the pretest and an apple in the posttest; a male student aged 13.2 years made only a drawing of a pear in the pretest, and a male student aged 13.7 years did not draw a scene. We analyzed only those drawings that concerned themes found in both pretest and posttest output of the same participant (for clarity, in order to use the same set of data all the time, in the analysis and testing of H1 we decided not to include individual drawings on those themes chosen in the pretest that the participants did not draw again in the posttest). A total of 50 drawings were taken into account, 25 made before and 25 after training. Forty percent of these drawings represented objects wholly explorable by touch (seven pretest drawings of an apple, one of a pear, and two of a table – and the same numbers of posttest drawings, respectively), 32% represented objects which it is impossible to wholly explore by touch (five pretest and five posttest drawings of a tree as well as three pretest and three posttest drawings of a house), and 28% represented scenes (six pretest and six posttest drawings of a room plus one pretest and one posttest drawing of a kitchen).

The figures show example sketches, made in the pretest, representing: an apple (Fig. 1), a pear (Fig. 2), a table (Fig. 3), a tree (Fig. 6), a house (Fig. 7), a room (Fig. 4), and kitchen (Fig. 5). Figures 6 and 7 juxtapose pretest and posttest drawings representing a tree and a house.

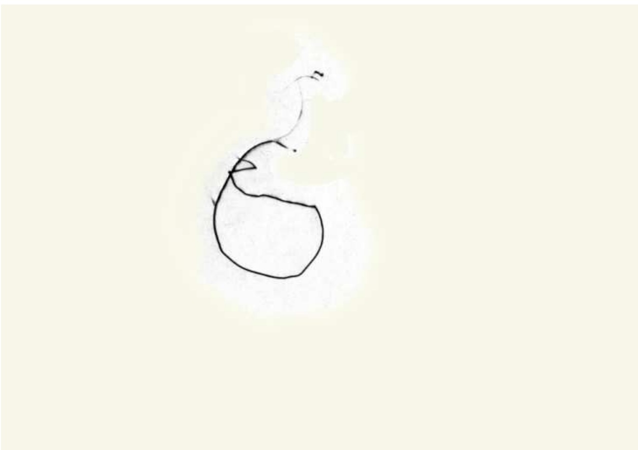

Figure 1. Drawing of an apple made by a male student aged 7.1 in the pretest.

Figure 2. Drawing of a pear made by a male student aged 13.7 in the pretest.

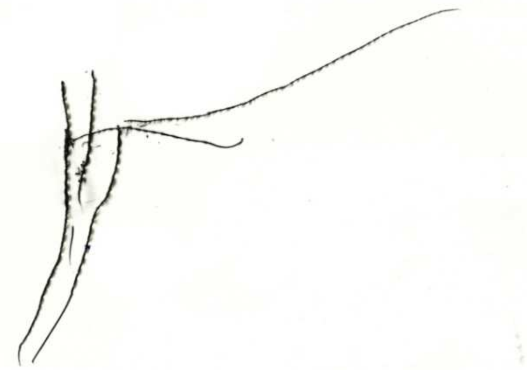

Figure 3. Drawing of a table made by a student aged 15.1 in the pretest.

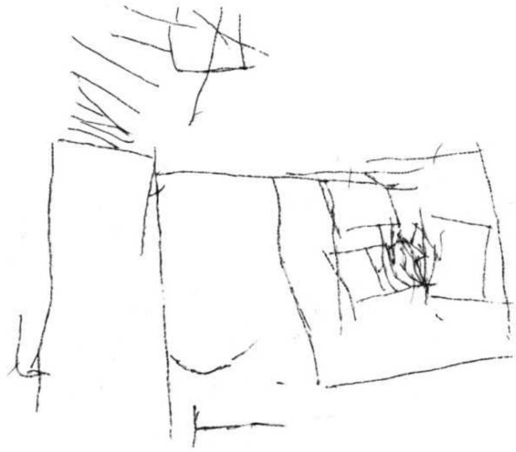

Figure 4. Drawing of a room made by a female student aged 7.0 in the pretest.

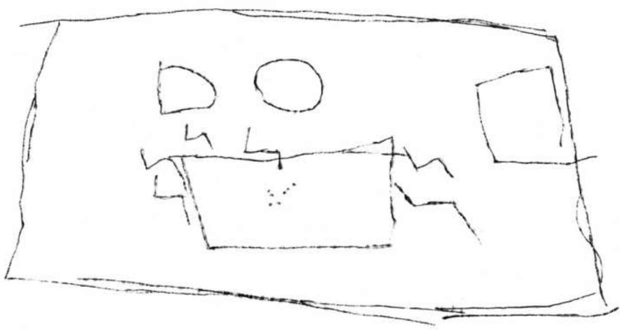

Figure 5. Drawing of the kitchen made by a female student aged 12.8 in the pretest.

The recognizability of drawings

Identification without clues. The first judge needed no clue to recognize what the drawing represented in 18 cases (which is 36% of all the drawings rated), of which 8 (32%) of correct recognitions concerned pretest drawings and 10 (40%) concerned those made in the posttest. The second judge succeeded in doing this 17 times (which is equal to 34% of all the pictures assessed), including 7 times (28%) in the case of pretest drawings and 10 times (40%) in the case of drawings made in the posttest. The difference between the frequency of correct recognitions was statistically significant neither in the case of the first judge nor in the case of the second one; the results of the McNemar chi-square test were as follows, respectively: $\chi^2(1) = .13$, $p = .724$, and $\chi^2(1) = .44$, $p = .505$.

Recognizability following a clue. After getting acquainted with the clue in the form of the titles of drawings (as well as the authors' comments, if any), the judges assessed the 50 drawings with an agreement rate of $r = .66$, $p < .001$. Descriptive statistics for averaged raw scores given by the judges to pretest and posttest drawings, for all the drawings jointly and for each thematic category separately, are presented in Table 2.

Table 2
*Recognizability of Pretest and Posttest Drawings: Means (*M*) and Standard Deviations (*SD*)*

Type of drawing – category	Pretest		Posttest	
	M	*SD*	*M*	*SD*
Objects wholly explorable by touch	3.35	1.42	3.65	2.03
Objects not wholly explorable by touch	3.56	1.88	4.50	1.56
Scenes	2.93	1.90	4.14	1.86
Uncategorized (total)	3.30	1.66	4.06	1.80

After computing *t*-tests for dependent samples, we found that the recognizability of drawings made in the posttest was significantly higher than the recognizability of those made in the pretest (see Table 2) in the case of all drawings analyzed jointly, $t(24) = -2.29$, $p = .031$, as well as for the category of drawings representing objects that it is not possible to explore entirely by touch, $t(7) = -2.38$, $p = .049$. Examples of pictures representing objects belonging to this category are shown in Figures 6 and 7. The recognizability of drawings representing objects explorable entirely by touch, $t(9) = -.67$, $p = .520$, as well as the recognizability of scenes, $t(6) = -1.32$, $p = .234$, did not change significantly in the posttest compared to the pretest.

Figure 6. Drawings of a tree made by a female student aged 12.8 in the pretest (left) and in the posttest (right).

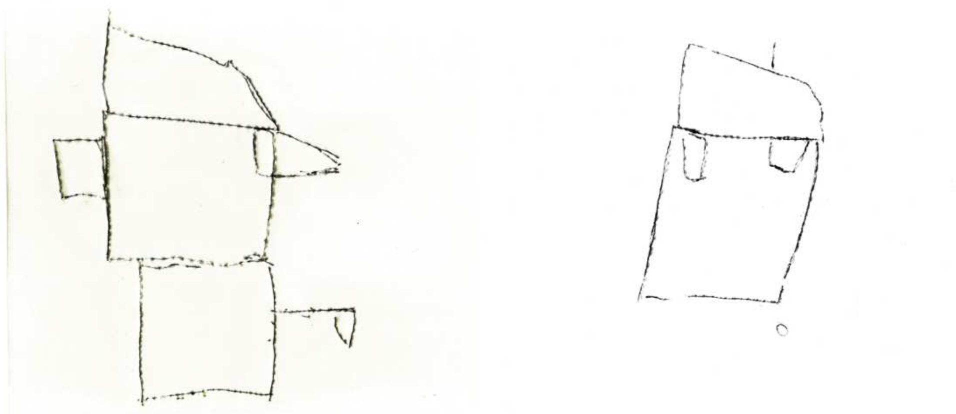

Figure 7. Drawings of a house made by a female student aged 13.7 in the pretest (left) and in the posttest (right).

THE RATING OF FORMAL ELEMENTS

The judges agreed in 96% about the occurrence of particular features in the assessed drawings (in the case of divergent ratings, they discussed to work out a common stance). A summary assessment of the frequency of specific formal features in pretest and posttest drawings is presented in Table 3. No significant differences in the frequency of occurrence in pretest vs. posttest drawings were found in the case of any of the features analyzed ($p > .05$ in the McNemar chi-square test; due to small number of occurrences, this test was not computed for all the features – this was not possible in the case of those whose number of occurrences in the pretest or in the posttest was 0 – see Table 3).

Table 3
*Frequency of Formal Features in Pretest and Posttest Drawings – Expressed as Percentages and as Numbers (*N*)*

Feature rated	Pretest drawing	Posttest drawing
Simple geometric shapes	28% (*N* = 7)	12% (*N* = 3)
Omitting many elements	60% (*N* = 15)	40% (*N* = 10)
Elements placed next to one another	57% (*N* = 4)	43% (*N* = 3)
The use of orthogonal projection	72% (*N* = 18)	72% (*N* = 18)
X-ray drawings	12% (*N* = 3)	8% (*N* = 2)
Drawings resembling comic strips	4% (*N* = 1)	0% (*N* = 0)
Folding-out drawing	12% (*N* = 3)	12% (*N* = 3)
Schematic shape	76% (*N* = 19)	80% (*N* = 20)
A large number of details	8% (*N* = 2)	12% (*N* = 3)
Transparency	16% (*N* = 4)	8% (*N* = 2)
Line-based drawing	14% (*N* = 1)	14% (*N* = 1)
Drawing in the form of a plan	29% (*N* = 2)	14% (*N* = 1)
Attempts at linear perspective	0% (*N* = 0)	12% (*N* = 3)
Excessive detail	0% (*N* = 0)	12% (*N* = 3)
Interposition	0% (*N* = 0)	0% (*N* = 0)
Planes in the picture	71% (*N* = 5)	71% (*N* = 5)
Aerial perspective	0% (*N* = 0)	0% (*N* = 0)
Chiaroscuro	0% (*N* = 0)	0% (*N* = 0)

Treating the sum of features characteristic for each stage of drawing development (expressed as a percentage) as a dependent variable, we found that, when all drawings were taken into account jointly, the percentage share of formal elements typical for failed realism was significantly higher than in the pretest, $t(24) = 2.41$, $p = .024$ (see Table 4). The percentage share of formal elements characteristic for the stage of intellectual realism, $t(24) = 0.53$, $p = .598$, as well as visual realism, $t(24) = -1.73$, $p = .096$, did not differ significantly. Performing separate analyses for particular thematic categories of drawings, we found no significant changes in the percentage share of features typical for the successive developmental stages in the posttest compared to the pretest ($p > .005$). Descriptive statistics for the analyzed variable in each thematic category of drawings are presented in Table 4.

Table 4
*Percentage Share of Features Characteristic for Each Stage of Drawing Development Found in Pretest and Posttest Drawings Belonging to Particular Thematic Categories – Descriptive Statistics: Means (*M*) and Standard Deviations (*SD*)*

Type of drawing – category	Pretest						Posttest					
	Failed realism		Intellectual realism		Visual realism		Failed realism		Intellectual realism		Visual realism	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Objects wholly explorable by touch	40.00	45.95	31.43	16.22	0.00	0.00	10.00	21.08	30.00	12.51	6.67	14.05
Objects not wholly explorable by touch	37.50	35.36	23.22	13.09	0.00	0.00	18.75	25.88	21.43	15.27	0.00	0.00
Scenes	57.14	31.71	28.57	14.14	9.53	8.91	52.38	26.23	26.98	10.84	11.91	12.60
Uncategorized (total)	44.00	38.45	27.99	14.53	2.67	6.24	24.67	29.31	26.41	13.03	6.00	11.67

Using analysis of variance for systems with repeated measurement, we compared the percentage share of features typical for each stage of drawing development that were present in the illustrations made by the students. The dependent variable was the sum of features characteristic for particular stages of drawing development (expressed as a percentage), and the independent variable was the successive developmental stages (failed, intellectual, and visual realism). For the drawings made in the pretest, a main effect of the analyzed factor was found, $F(2, 48) = 16.87$; $p < .001$; $\eta^2 = .41$. Based on post hoc Tukey's tests, we found that the percentage share of formal features characteristic for the stage of visual realism was significantly lower than the percentage share of features typical for the stages of failed realism, $p < .001$, and intellectual realism, $p = .003$ (see Table 4). Moreover, we found a lower – tendency-level – percentage share of features typical for the stage of intellectual realism than than of features typical for failed realism, p = .076 (see Table 4). An analogous analysis performed for the drawings made in the posttest also revealed a significant main effect, $F(2, 48) = 8.09$, $p < .001$, $\eta^2 = .25$. Based on the results of Tukey's tests, we found that the percentage share of formal features characteristic for the stage of visual realism was significantly higher than the percentage share of features typical for the stages of failed realism, $p < .001$, and intellectual realism, $p = .003$ (see Table 4). The percentage shares of characteristics typical for the stages of intellectual and failed realism did not differ significantly, $p = .948$.

DISCUSSION

The first hypothesis was verified positively. It has been empirically demonstrated that drawings made by blind learners contain more formal elements characteristic for the stages of failed and intellectual realism than ones typical for the visual realism stage. We found this pattern both with regard to drawings made at the beginning of the study (in the pretest) and with regard to those made after training with a transfograph (in the posttest). We also found that the drawings made before training were characterized by a slightly higher proportion of features representing failed realism than intellectual realism (the difference reaching the statistical tendency level). This attests to a delay in drawing development in blind people compared to sighted people by at least one developmental stage, which had already been suggested by previous studies on blind people's drawing skills (e.g., D'Angiulli & Maggi, 2003; Heller et al., 1995; Kennedy, 1993; Millar, 1975; Shiu & I, 2010; Szuman, 1967). On average, the students examined were nearly 13 years old; their age ranged between 7 and 15. Normally developing children and adolescents in this age group are in the stage of intellectual realism – in the first years of elementary school – or visual realism, starting at about the age of 9 (Luquet, 2001/1927). In the graphic works of blind people, features typical of the visual realism stage hardly manifested themselves at all (except planes in the picture, a device fairly often used in drawings representing scenes). The drawings (made both in the pretest and in the posttest) were difficult to identify, too. This means that the representations in them were not very realistic, which is typical for the stage of failed realism. In over 60 percent of all the assessed drawings, the judges were unable to identify the represented objects correctly (a nearly identical result was obtained in the study on congenitally blind 12-year-old learners conducted by D'Angiulli & Maggi, 2003).

The second hypothesis, according to which drawings made by blind students after training with a transfograph are more recognizable than drawings made before training, was only partly confirmed. When no clues were provided – that is, when the task required specifying what a given drawing represented, the judges gave correct answers equally often in the case of drawings made before and after training with a transfograph. By contrast, when they already knew the title of the work, they rated the objects and scenes drawn after training with a transfograph as more recognizable than those drawn before training (which manifested itself especially for the category of drawings representing objects impossible to explore in their entirety by touch). The partial confirmation of the hypothesis may have resulted from the fact that the participants' drawings were not very realistic and, as such, not very informative; consequently the identification of the rather ambiguous objects represented in them without any clue was a very difficult task. The higher recognizability rating of drawings with known titles that were made after training with a transfograph than before training may stem from the fact that, having understood the relationship between the three-dimensional object and the two-dimensional image, blind students become more eager to draw (Marek & Szubielska, 2011). Having a stronger motivation to draw, they put more effort into making a graphic work and, as a result, capture the shape of the objects depicted more accurately. The study partly confirmed the third hypothesis – in drawings made after training with a transfograph we found fewer characteristics typical for the stage of failed realism than in drawings made before training (by contrast, we found no increase in the percentage of features of intellectual or visual realism in the posttest compared to the pretest). Having understood the convention of drawing in the form of a projection, blind learners probably try to represent the objects they sketch in this particular manner. In doing so, they attach greater importance to actual shape of the objects and to the spatial arrangement of their components.

To sum up, on the one hand, the presented study revealed a delay in the drawing development of blind children amounting to at least one developmental stage. On the other hand, it showed that this delay can be fairly quickly made up for by using appropriate typhlopedagogical aids. One training with a transfograph was enough to reduce the percentage of traits typical for the stage of failed realism and for the drawings to become more recognizable to viewers (who knew what their subject was).

We believe that similar studies should be conducted in the future; they should be supplemented by a control group of sighted individuals drawing blindfolded and should cover a wider age range (preschoolers, schoolchildren, adolescents, and adults). In our opinion, it would also be interesting to compare drawing development – not only in terms of the ability to represent reality realistically in drawings but also in terms of creative expression – over a span of many years (using the longitudinal research strategy) and across cultures.

REFERENCES

Arditi, A., Holtzman, J. D., & Kosslyn, S. M. (1988). Mental imagery and sensory experience in congenital blindness. *Neuropsychologia, 26*, 1-12.

Chojecka, A., Magner, M., Szwedowska, E., & Więckowska, E. (2008). *Nauczanie niewidomych dzieci rysunku*. Laski: The Society for the Care of the Blind.

Claudet, P. (Ed.) (2009). The typhlo and tactus guide to children' books. Talant: Les Doigts Qui Revent.

Czerwińska, K. (2008). Rysunek wypukły jako pomoc dydaktyczna w nauczaniu języków obcych – doniesienia z badań. In K. Czerwińska (Ed.), *Adaptacja pomocy w nauce języków obcych osób niewidomych i słabo widzących* (pp. 36-69). Warsaw, PL: Wydawnictwo Akademii Pedagogiki Specjalnej.

D'Angiulli, A., & Maggi, S. (2003). Development of drawing abilities in a distinct population: Depiction of perceptual principles by three children with congenital total blindness. *International Journal of Behavioral Development, 27*, 193-200.

Dulin, D., & Hatwell, Y. (2006). The effects of visual experience and training in raised-line materials on the mental spatial imagery of blind persons. *Journal of Visual Impairment & Blindness, 100*, 414-424.

Farrenkopf, C., & Davidson, I. F. (1992). The development of perspective-taking abilities in young blind children. *RE:view, 24*, 7-22.

Francuz, P. (2013). *Imagia. W kierunku neurokognitywnej teorii obrazu*. Lublin: Wydawnictwo KUL.

Gill, R. (1997). *Zasady rysunku realistycznego*. Łódź: Wydawnictwo Galaktyka.

Heller, M. A. (2006). Picture perception and spatial cognition in visually impaired people. In M. A. Heller & S. Ballesteros (Eds.), *Touch and blindness. Psychology and neuroscience* (pp. 49-71). Mahwah, NJ: Lawrence Erlbaum Associates.

Heller, M. A., Calcaterra, J. A., Tyler, L. A., & Burson, L. L. (1996). Production and interpretation of perspective drawings by blind and sighted people. *Perception, 25*, 321-334.

Heller, M. A., Kennedy, J. M., & Joyner, T. D. (1995). Production and interpretation of pictures of houses by blind people. *Perception, 24*, 1049-1058.

Hohensee-Ciszewska, H. (1976). *Podstawy wiedzy o sztukach plastycznych*. Warsaw, PL: Wydawnictwa Szkolne i Pedagogiczne.

Janowski, J. (2007). Przedstawienia wyobrażonej przestrzeni na obrazach. In P. Francuz (Ed.), *Obrazy w umyśle. Studia nad percepcją i wyobraźnią* (pp. 63-110). Warsaw, PL: Wydawnictwo Naukowe Scholar.

Jolley, R. P. (2010). *Children and pictures: Drawing and understanding*. Hoboken, UK: Wiley-Blackwell.

Kennedy, J. M. (1993). *Drawing and the blind: Pictures to touch*. New Haven, CT: Yale University Press.

Kennedy, J. M., & Juricevic, I. (2003). Haptics and projection: Drawings by Tracy, a blind adult. *Perception, 32,* 1059-1071.

Kennedy, J. M., & Juricevic, I. (2006). Blind man draws using diminution in three dimensions. *Psychonomic Bulletin & Review, 13,* 506-509.

Kielar-Turska, M. (2000). Rozwój człowieka w pełnym cyklu życia. In J. Strelau (Ed.), *Psychologia. Podręcznik akademicki. Podstawy psychologii* (pp. 285-332). Gdańsk: Gdańskie Wydawnictwo Psychologiczne.

Lowenfeld, V., & Brittain, W. (1977). *Twórczość a rozwój umysłowy dziecka*. Warsaw, PL: Wydawnictwo Naukowe PWN.

Luquet, G. H. (2001/1927). *Children's drawings/Le dessin enfantin*. London: Free Association Books.

Marek, B. (1997). Before a blind child can read a map. First steps in tactile graphics. Paper presented at the 10th World ICEVI Conference, São Paulo, Brasil, Aug 3-8, 1997.

Marek, B., & Szubielska, M. (2011). Introducing young learners to tactile graphics: Simple tools for explaining complex problems. Paper presented at Statewide Vision Resource Centre Tactile Graphics Conference. Melbourne-Nunawading, Australia.

Marek, B., & Szubielska, M. (2013). *Grafika dotykowa w edukacji i rehabilitacji osób niewidomych*. Paper presented at the 1st Contexts of Rehabilitation Psychology Interdisciplinary Conference, Lublin.

Millar, S. (1975). Visual experience or translation rules? Drawing the human figure by blind and sighted children. *Perception, 4*, 363-371.

Młodkowski, J. (1998). *Aktywność wizualna człowieka*. Warsaw and Łódź, PL: Wydawnictwo Naukowe PWN.

Pathak, K., & Pring, L. (1989). Tactual picture recognition in congenitally blind and sighted children. *Applied Cognitive Psychology, 3,* 337-350.

Piaget, J. (1972). *Myślenie i mowa dziecka*. Warsaw, PL: Wydawnictwo Naukowe PWN.

Piskorska, A., Krzeszowski, T., & Marek, B. (2008). *Uczeń z dysfunkcją wzroku na lekcji angielskiego. Wskazówki metodyczne dla nauczycieli*. Warsaw, PL: University of Warsaw.

Roliński, F. (1962). *Perspektywa odręczna*. Warsaw, PL: Wydawnictwo Arkady.

Shiu, C.-J., I, B. (2010). The possibility of replacing visual sense with tactile sense in the spatial representation of the blind. *Asia-Pacific Journal for Arts Education, 8*, 1-29.

Szubielska, M., & Marek, B. (2012). Comprehension of tactile graphics by school-aged children with severe visual impairment: The role of tactile perception and spatial imagery. In *15th European Conference on Developmental Psychology. 23-27 August 2011 – Bergen – Norway. Merimond International Proceedings* (pp. 121-130). Bologna: Medimond Publisher.

Szubielska, M., & Marek, B. (2015). The role of visual experience in changing the size of objects in imagery processing. *Journal of Visual Impairment & Blindness, 109*, 43-53.

Szubielska, M., & Niestorowicz, E. (2013). Twórczość plastyczna jako forma wspierania rozwoju osób niewidomych i głuchoniewidomych. In D. Müller & A. Sobczak (Eds.), *Rozwój i jego wspieranie w perspektywie rehabilitacji i resocjalizacji* (pp. 89-104). Łódź: Wydawnictwo Uniwersytetu Łódzkiego.

Szuman, W. (1967). *O dostępności rysunku dla dzieci niewidomych*. Warsaw, PL: Państwowe Zakłady Wydawnictw Szkolnych.

Więckowska, E. (2009). Zasady redagowania tyflografiki. *Tyfloświat, 3,* 7-13.

Zeki, S. (1999). *Inner vision. An exploration of art and the brain*. Oxford: Oxford University Press.